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UNITIZED HYBRID ROCKET SYSTEM

CROSS-REFERENCE TO RELATED APPLICATION(S)

This application claims the benefit of U.S. Provisional Application 60/458,296 filed March 28, 2003.

BACKGROUND OF THE INVENTION

This invention relates to a hybrid rocket system useful, for example, to propel a winged suborbital spacecraft, but not limited to that application. In contrast to solid-fuel and liquid-fuel rockets, a hybrid rocket motor uses both types of fuel. That is, a fluid oxidizer such as nitrous oxide (N_2O) is used to burn a solid fuel. The oxidizer is held in a pressurized tank, and the solid fuel (such as HTPB, or hydroxyl-terminated polybutadiene) is cast on the inner walls of a hollow, and typically tubular combustion-chamber housing or motor extending rearwardly from the oxidizer tank, and terminating in a throat and nozzle. A pilot-controlled valve admits oxidizer to the housing, and an igniter (such as a spark or flame type) initiates combustion.

This invention is directed to two significant improvements. First, to a simplified method of securing and mounting the rocket to a spacecraft fuselage or associated structure; and second, to an integrated motor construction which sharply limits possible leakage paths for improved reliability and safety.

SUMMARY OF THE INVENTION

The hybrid rocket system of this invention is characterized by use of an oxidizer tank having a cylindrical midsection which can be bonded to a spacecraft inner surface by a layer of elastomeric adhesive. An elongated solid-fuel motor case is mechanically rigidly secured to a central rear

surface of the tank, and the case terminates in a throat and nozzle. The elastomeric-adhesive bonding of tank to spacecraft forms the sole support for the rocket system, and separate support for the motor case is not required.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a side view of a hybrid rocket as mounted in a winged spacecraft (shown in cross section);

Fig. 2 is an exploded view of components of the rocket;

Fig. 3 is a sectional perspective view of a forward end of a solid-fuel motor case of the rocket;

Fig. 4 is a partial sectional view shown by the junction of the motor case with an oxidizer tank; and

Fig. 5 is a partial sectional view of the oxidizer tank.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Fig. 1 shows a hybrid rocket 10 as mounted in a winged suborbital spacecraft fuselage 11, partially shown in cross section, and having a pilot compartment 12. The major components of rocket 10 are an oxidizer tank 14 with an elongated cylindrical midsection 15 secured to an inner surface 17 of the fuselage, the tank having a rear bulkhead (described below) to which is secured a cylindrical motor 19 terminating in a nozzle 20. A retractable landing gear and the spacecraft wing and empennage are omitted in Fig. 1 for clarity.

Oxidizer tank 14, shown in cross section in Fig. 5, has a relatively thin (e.g., 0.1-0.125 inch) inner liner 22 of an epoxy-fiberglass prepreg composite material. The inner liner is overwound with a layer 23 of graphite-fiber tow coated with an epoxy matrix. The thickness of the tow/epoxy layer is about one-fourth inch in cylindrical midsection 15 of the tank, and gradually thickens toward the opposed tank ends to

about 1-1/2 inch where the tank captures and is in sealed engagement with cylindrical forward and rear flanges 26 and 27 (Fig. 5).

Sealingly clamped to forward flange 26 is a forward bulkhead 29 which closes the front end of the tank, but provides a valved inlet (not shown) for loading of oxidizer. Similarly sealingly clamped to rear flange 27 is a forwardly convex rear bulkhead 30 which closes the rear end of the tank. An oxidant delivery valve and igniter system (not shown) are mounted on the rear bulkhead within the tank.

Tank cylindrical midsection 15 is covered by a cylindrical skirt 32 which, in a preferred form, is made of about eleven plies or layers of flexible fiberglass cloth, the adhesively bound plies being oriented at 45 degrees to the longitudinal axis of the tank. The inside diameter of the skirt is slightly larger than the outside diameter of the tank midsection, enabling injection of a thick (about 0.1 inch) layer of an elastomeric adhesive (Proseal P5890, Class B, made by PRC Desoto is satisfactory) to bond the skirt to the tank.

The thus-bonded skirt and tank make a slip fit within a mating inner cylindrical surface 34 of a fuselage of spacecraft 11, enabling injection of a thin (about 0.02 inch) layer of a rigid bonding adhesive to secure the tank and skirt to the fuselage. An adhesive such as Hysol 9396 is satisfactory. The tank-skirt and skirt-fuselage bondings form the sole support for rocket 10 within the spacecraft.

Fig. 4 is a partial cross-sectional view of the rigid junction of motor 19 to oxidizer-tank rear flange 27 and rear bulkhead 30. Motor case 36 has a silicon-phenolic inner liner 37 of about 0.1-inch thickness, and an outer wrap 38 of carbon-fiber tow of about 0.3-inch thickness. Solid fuel 39 is cast within the case, leaving open portions around the case centerline. A compression-molded head insulation 40 is formed

ahead of the solid fuel, and has a forwardly convex front end 41 following a mating curvature of the rear end of bulkhead 30. The forward end of case 36 is outwardly flared to seat against a cylindrical steel wedge 43 of triangular cross section, and having a front surface 44 with an O-ring seal 45 seated against an outwardly extending cylindrical flange 46 on rear bulkhead 30.

An aluminum clamping ring 50 having a forwardly and outwardly tapered inner surface 51 fitted over the forward end of the motor case, and against the rear surface of flange 46. A number of threaded fasteners 52 extend through mating openings in ring 50, flange 46, and flange 27 to nuts 53 to tightly clamp those components together, thereby rigidly securing the motor case to the tank. Additional O-ring seals 54 are seated in flange 46 and a forwardly extending ring 55 formed integrally with the rear bulkhead. A perforated cylindrical tube 56 is secured to ring 55, and extends forwardly within the oxidizer tank to provide a slosh baffle.

The oxidizer tank is loaded with nitrous oxide pressurized to about 700 psi, at which pressure the oxidizer is a liquid. Outward swelling of the pressurized tank is at least partially absorbed by the thick layer of elastomeric adhesive bonding the tank skirt to the fuselage, and this adhesive layer also absorbs and damps motor vibrations.

Apart from cylindrical midsection 15, the oxidizer tank roughly approximates a sphere providing a pressure vessel strong enough to support the loads imposed by a fired motor. This strength permits the motor to be cantilevered off the rear end of the tank, and without further support from the fuselage. This single connection enables easy replacement of the motor (typically a single-use component), as well as accomodating motors of varying length, and reducing the number of possible leakage paths. Further, no additional weight is

incurred in motor support, as the strong tank/fuselage mounting supports the entire rocket system.